RESEARCH OF DRY PLANT CONCENTRATES – INGREDIENT OF A FOOD HEALTH IMPROVEMENT

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Abstract

It is suggested to perfect technology of production of emulsive foodstuffs, as most consumed by all groups of population of Ukraine, by introduction to compounding of secondary wastes of exit-juice production and vine making as dry concentrates. Such method of enriching of foodstuffs will allow to bring down the deficit of necessary micro- and macronutrients, biologically active substances, and also to bring down indexes on the number of peroxide in the process of storage of low-caloric sauces due to being of natural antioxidants in powdered plant and vegetable material. Experiments were conducted for determination of micro- and macroelement composition and content of sum of polyphenolic substances samples of powdered plant and vegetable material. Samples with the optimal above-mentioned indexes were revealed and samples for the next stage of researches were chosen.

The data plan experiment on the effect of temperature and time storage of powdered vegetable raw materials in the amount polyphenols (% wt) in samples of powdered vegetable raw materials used in the suggested corrections storage term low-calorie sauces based on secondary products of juice and wine manufacturing in recipes and calculations in compounding on productions. It was substantiated the choice of grape skin powder as bioactive addition in the emulsive foodstuffs for health improvment purposes, as a sample that has optimal indexes for micro- and macronutrients composition and maintenance of natural antioxidants of polyphenolic nature.

Keywords: biologically active substances, products for health improvement purposes, powders produced from vegetable raw materials and stuffs.

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1. Introduction

Research in nutritiology that conducted by scientists [1–3] in recent years has shown that the daily foodstuffs consumed by people can be not only delicious and quick to prepare, but also useful and able to enrich the diet or ration with biologically active substances (BAS) – flavonoids, micro- and macronutrients, dietary fibers and so on. The data concerning the usage of various fat-containing products, dried vegetable concentrates as food additives to [4, 5] obtained by the method of cryogenic grinding, vacuum and freeze drying. This method allows preserve the basic amount of biologically active substances in almost native state. Foodstuffs that are enriched in this way in vitamins, dietary fibers and other useful biologically active substances allow compensate the lack in the aforementioned nutrients and reduce the risk of XXI century disease rising – diabetes, obesity, vegetative-vascular lesions and others. [6]. The introduction of the formulation of fruit or vegetable powders not only enriches the product with biologically active ingredients, but also gives the new technological features for product, without use of artificial ingredients or using them in a minimal amount [7–10]. The most prevalent fruit and vegetable powdered concentrates, which are used as a source biologically active substances: carotenoids (pumpkin, carrots) polyfructose (elamin, inulin), spices are those not only enrich foodstuffs with micro- and macronutrients, dietary fibers and other active substances, but also to give the product a pleasant taste, color and flavor.

Among antioxidants of vegetable raw materials it should pay attention to grape polyphenols, whose properties are much studied in [11, 12]. Such antioxidants in plant rawstuffs as resveratrol and quercetin are worthy. The biochemical properties of resveratrol (3,4,5 trihydroxy-trans-stilbene) – bioflavonoids and natural phytoalexin were investigated and substantiated in clinical settings. [13–18]. Their anti-inflammatory, disagreggative, antioxidant activity have been proved, which proves the feasibility of its practical application in the food industry as a dried vegetable concentrates of fruits and berries, where the aforementioned bioflavonoid is present [19, 20]. High antioxidant ability of resveratrol is due to the fact that by nature it is phytoalexin – a substance produced by plants in the conditions of their infection by bacteria and fungal organisms, i. e this is a defensive reaction to the negative actions that can cause the death of a living organism. This property of resveratrol can be used in food industry as an inhibitor of lipid peroxidation, i. e. shelf life prolongation of food products such as products made in oil and fat industry, without the use of artificial antioxidants.

We must pay attention to the shortage of micro- and macronutrients in human nutrition such as sodium, potassium, calcium, iron, copper and so on. Lack of necessary micro- and macronutrients is primarily concerned with the fact that refined food and foodstuffs that have been subjected to a long process of technological processing, consist virtually of fat, protein and «fast» carbohydrates [21]. This leads to a number of diseases among the population of Ukraine, such as obesity, diabetes, diseases of the gastrointestinal tract. Highly efficient and fast way to solve the shortage of micro- and macronutrients is the development of mass-consumption food products such as mayonnaise enriched with deficit substances [22].

On the basis of the above-mentioned data an actual and perspective on this time task is an improvement of technologies of production of foodstuffs on the basis of dry vegetable concentrates with high maintenance of polyphenols and able to cover the deficit of necessary micro- and macronutrients. The ground of choice of raw material and research of its properties for the further use in compounding of emulsive foodstuffs presents by part of research work in this direction.

2. Materials and methods of dry plant material concentrates

2. 1. Materials of research

As materials of research the following powder plant material has been applied, namely blackcurrant, orange peel, apple red, Black Pearl and Muscat White grape skins (Ukraine).

Obtaining of fine powdered plant and vegetable material, size: 0,5...100 mm, has been accomplished by drying according UVET-technology (activation method for drying (dehydration) of product while its simultaneous grinding into a powder) on the universal drying-crushing equip-

ment UVET-005. Drying was carried out in full compliance with the requirements of hygienic and sanitary safety at 40–45 °C and relative humidity of the finished samples of 5 %.

2. 2. Methods and equipment used in the experiment

Method of determination of micro- and macronutrient composition and content of powdered plant raw material.

Research of micro- and macronutrient composition content of powdered plant raw material has been carried out by spectrometric method using X-ray fluorescence spectrometer «Elvax» (Ukraine).

Method of determination of micro- and macronutrient composition content using X-ray fluorescence spectrometer is based on collecting and analyzing the spectrum that has been obtained after initiation of characteristical x-ray radiation, which occurs during the transition of atoms from the excited in the ground state. Atoms of different elements emit photons with strictly defined energies, and by measuring of them tone we can determine qualitative element composition. In order to measure the number the quantity or content of element the radiation intensity with a certain energy is registered. This method allows to obtain accurate results for quantitative composition of micro- and macronutrients, that is widely used in food, cosmetic, pharmaceutical and other industries.

In order to determine the quantitative content in the samples the method of fundamental parameters has been applied – the method of so-called «non-standard» analysis. These is a base for program of spectrometer that allows to calculate the concentration of any set of elements in the sample. During the experiment the intensity of X-rays irradiation has been measured, the value of which has been proportional to the mass concentration (%) of micro- and macronutrients, which was being deternined.

Qualitative determination of polyphenolic compounds in vegetable raw materials powders has been carried out as follows. Qualitative reaction for determining and showing the presence of polyphenolic compounds is based on the interaction of polyphenols filtrate with 5 % solution of aluminum chloride – and as a result chelate complexes are formed by hydrogen bonds that occur between the carbonyl and hydroxyl groups and aluminum ion; there is a yellow-green color as a positive reaction to polyphenols [23]. Depending on the content of polyphenolic substances in investigated samples a colouring of filtrate is observed with varying intensity – from slightly yellow to yellow-green.

Studies on content amounts of polyphenol compounds (flavonoids) in powdered plant and vegetable material have been carried out in accordance with the State Pharmacopoeia of the USSR by measuring of optical density in powders extract solutions using the spectrophotometer at a wavelength of 430 nm in a cell with a layer thickness of 10 mm [23].

The determination of the polyphenolic substances (flavonoids) has been carried out according to the following procedure. Analytical sample material has been crushed to the size of particles are able to pass through a sieve with holes of 1 mm. About 1 g (exact weight) of material has been placed in a flask with a capacity of 150 cm^3, after that 30 cm^3 of 90 % alcohol solution containing 1 % of concentrated hydrochloric acid has been added. Then the flask was attached to the flask reflux and heated in a boiling water bath for 30 minutes. After that the flask was cooled to room temperature and the content was filtered through a paper filter into a volumetric flask of 100 cm^3. Extraction was repeated once more according to the above method, then 1 time – by 90 % alcohol for 30 minutes. Extracts were filtered through the same filter in the same volumetric flask,after that they were washed with 90 % alcohol filter and adjusted the volume of filtrate 90 % alcohol to the mark (solution A).

In a volumetric 25 cm^3 flask 2 cm^3 of solution A were introduced, then 1 cm^3 of 1 % solution of aluminum chloride in 95 % alcohol solution was added and solution volume was adjusted by 95 % alcohol to the mark. After 20 minutes the solution was measured in order to determine optical density on a spectrophotometer at a wavelength of 430 nm in the cell with a layer thickness of 10 mm. Solution consisting of 2 cm^3 of solution A has been used as comparison solution, preliminarly led to a special mark in the volumetric 25 cm^3 flask using a 95 % alcohol.

Total content amount of polyphenolic substances (flavonoids) in terms of quercetin and absolutely dry raw materials in percentage (X, %) has been calculated using the formula:

$$X = \frac{D \times 25 \times 100 \times 100 \times 100}{764{,}6 \times m \times 2 \times (100 - W)}, \quad (1)$$

where D – optical density of the test solution; 764.6 – specific absorption rate for quercetin complex of aluminum chloride at 430 nm; m – mass of raw materials in grams; W – loss in weight diring the drying of raw materials expressed as a percentage.

Experiments from research of dependence of expiration of powdered plant and vegetable material are conducted in accordance with the plan of experiment «composition – property». As factors a temperature and storage time of samples of the investigated raw material are accepted, as functions of review is the amount of polyphenols in the samples.

Research has been conducted in repeating three times. Research results have been processed using the methods of mathematical statistics: determation of relative error with confidence probability P=95 %.

3. The results of the accomplished research and studies of powdered vegetable concentrates samples

Results of the study of micro- and macronutrient composition of powdered plant and vegetable material are shown in **Table 1**.

During the determination of micro- and macronutrient composition of powders the relative error does not exceed 0.4 % at a confidence probability P=95 %.

The data in **Table 1** show a variety of micro- and macronutrient composition of powdered plant and vegetable material. Potassium and calcium content, necessary for normal function of cardial-vascular system and blood circulation [24], is respectively 42–96 % and 7–57 % depending on the sample of investigated materials. Magnesium and chrome, minerals that are responsible primarily and first of all for carbohydrate metabolism and strengthen bone tissue [25], have been found in their maximum amount in powedered Muscat White grape skins sample.

Table 1

Micro- and macronutrient composition of powdered plant and vegetable material

Micro- and macronutrients	Micro- and macronutrient content in powdered plant and vegetable material, %				
	Blackcurrant	Shred of orange peel	Red apple	Dark Pearl grape skins	Muskat White grape skins
Ca	7,289	57,737	13,993	27,244	17,481
Cr	0,0430	0,048	0,210	0,131	9,311
Cu	0,002	0,001	–	0,003	–
Fe	0,037	0,340	0,354	0,056	4,874
K	92,543	42,168	85,427	72,535	65,237
Na	–	–	–	0,602	0,743
P	0,002	0,003	–	0,003	–
Mg	0,005	0,001	0,010	0,011	0,910
S	0,001	0,001	–	0,002	–
Zn	0,006	0,001	0,006	0,181	0,160

So important for metabolism as a trace element, zinc is defined in large quantities in Black Pearl grape skins, but there are iron and calcium in rather a small amounts as the substances that prevent the absorption of trace elements, and these can now identify the investigated powder as the source of deficit micro- and macronutrients in formulations of emulsion products made for health improvement purposes.

A study of BAS in powdered plant and vegetable material, namely regarding the content of polyphenolic substances (flavonoids), has been carried out. Data obtained during the research are shown in **Fig. 1.**

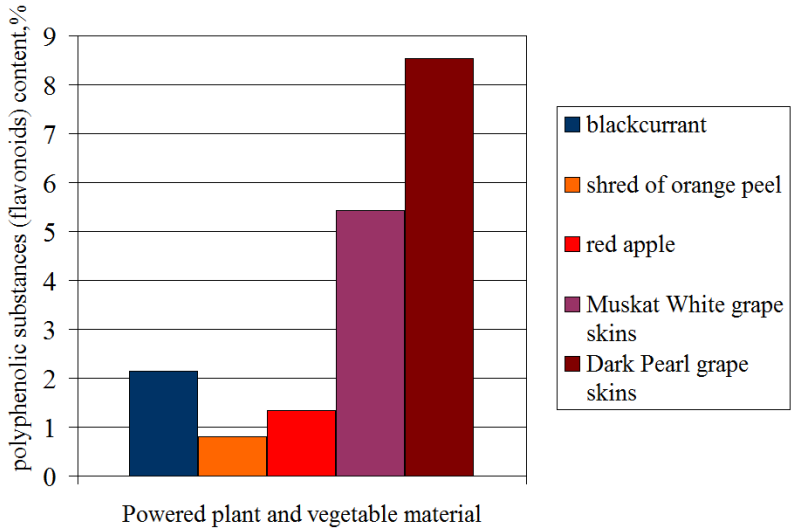

Fig. 1. Polyphenolic substances (flavonoids) content in samples of powdered plant and vegetable material

During the determination of polyphenolic substances (flavonoids) content in samples of powdered plant and vegetable material the relative error has not exceeded 0.4 % at a confidence probability P=95 %.

As shown in **Fig. 1**, during determining of polyphenolic substances (flavonoids amount in terms of quercetin it has been found that the smallest content of polyphenols (2 %) has been observed in samples obtained from blackcurrant, orange peel and red apples. And in samples of powdered grape skins the polyphenolic BAS content has been much higher (up to 10 %) than in the other investigated samples, so they can be used as a dietary or biologically active supplement − a source of polyphenols and also act as antioxidants, extending the storage time of emulsion products for health improvement purposes.

Influence of temperature and storage time of samples is investigated on content of polyphenols in powdered plant and vegetable material.

For an experiment select samples with maximal content of polyphenolic substances of Black Pearl grape skin powder and Muscat White grape skin powder. Data obtained during the research of Black Pearl grape skin powder are shown in **Fig. 2.**

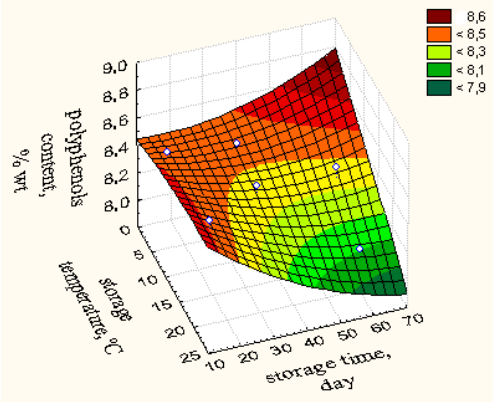

Fig. 2. Diagram of dependence content of polyphenols of Black Pearl grape skin powder from a temperature and storage time

Equalization of regression looks like for the calculation of function of review:

$$У(X_1, X_2)=8,6848+0,0005\times X_1-0,0093\times X_2+0,05262\times X_1\times X_1-0,0005\times X_1\times X_2+0,0002\times X_2\times X_2,$$

where X_1 – storage temperature, °C; X_2 – storage time, day.

As shown in **Fig. 2**, the surface area of maximum response corresponds to the polyphenols content storage temperature 0...7 °C and the value of the storage time of 55...70 days (polyphenols content is 8.8...8.6 % wt.).

Data obtained during the research of Muscat White grape skin powder are shown in **Fig. 3**.

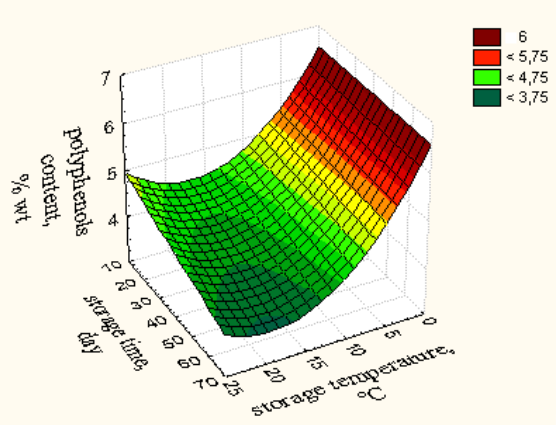

Fig. 3. Diagram of dependence content of polyphenols of Muscat White grape skin powder from a temperature and storage time

Equalization of regression looks like for the calculation of function of review:

$$У(X_1, X_2)=6,5522-0,249\times X_1+0,0606\times X_2+0,0077\times X_1\times X_1-0,0007\times X_1\times X_2+0,0044\times X_2\times X_2,$$

where X_1 – storage temperature, °C; X_2 – storage time, day.

As shown in **Fig. 3**, response surface area of maximum polyphenols content corresponding to storage temperature of 0...4 °C and does not depend of the storage time (polyphenols content is 6.5 ... 5.7 % wt.).

Thus, quantitative dependences (as regressive models) of content of polyphenols are set in grape skin powder of different sorts from the cross-coupling of storage temperature and storage time. Mathematical dependence should be used in calculating and correcting storage time of powdered skin grape varieties of data on enterprises that apply these raw materials in production.

4. Discussion of results of research of the dried vegetable concentrates properties as a source of biologically active substances in emulsion products for health improvement purposes

According to obtained data (**Table 1**) it can be argued that the powder plant and vegetable material have a wide range of micro- and macronutrients content, that are deficit substances, and it can be preserved and saved in terms of compliance with all requirements of production data samples for these technologies. For optimal ratio of micro- and macronutrients (bioavailability and assimilation by the body) [24, 25] as the biologically active ingredients in the formulations of emulsion products for health improvement purposes it is advisable to choose powdered grape skin for the usage.

Results of the research aimed to determine the content of polyphenolic substances (flavonoids) (**Fig. 1**) shown that the maximum content of natural antioxidants identified in Black Pearl grape skin powder and Muscat White grape skin powder. It also testifies in behalf on select raw material as constituent of products for health improvement purposes.

Obtained mathematical dependences of the polyphenols content in Black Pearl grape skin powder and Muscat White grape skin powder, depending on temperature and storage time

(**Fig. 2**, **3**) should be used in the calculation of the recipes on enterprises, also timing correction storage health improvement purposes on the basis of secondary products of juice manufacturing and wine making.

The research is enable to reconsider the already known ways to use wastes of juice and wine production (mostly for production of alcohol and tartaric acid). It is necessary to introduce new technologies to use wastes of plant and vegetable raw material, valuable in biological meaning, in food industry.

5. Conclusions

Micro- and macronutrients composition of vegetable powders obtained by activation drying has been investigated and samples have been analyzed with regard to the content of necessary nutrients. It has been found that samples of vegetable raw materials have content of calcium to 57 % and potassium to 96 %. The maximal amount of magnesium, chrome and zinc is educed in grape skin powders.

The content of polyphenolic antioxidants in samples of powdered vegetable and plant material has been defined and the obtained data has been analyzed in order to determinate the samples with maximum yields of the total amount of polyphenols. The maximal indexes (to 10 %) of content of sum of polyphenolic substances are educed in the samples of grape skin powders. It has been received mathematical dependencies of polyphenols content depending on the temperature and storage time for samples with the highest content of polyphenols – Black Pearl grape skin powder and Muscat White grape skin powder. It has been substantiated the use of powdered grape skin as a source of biologically active products for health improvement purposes to provide health care properties, increasing the biological value and prolong its storage by the presence of antioxidant polyphenolic nature. Food, additionally enriched with natural antioxidants, micro- and macronutrients and minerals have a positive impact on human health.

References

[1] Telezhenko, L. M. (2004). Naukovi osnovy zberezhennia biolohichno aktyvnykh rechovyn v tekhnolohiiakh pererobky fruktiv ta ovochiv, 38.

[2] Poliakova, A. V. (2008). Vykorystannia roslynnykh dobavok antyoksydantnoi dii v tekhnolohii vyrobiv z lystkovoho tista, 23.

[3] Makarenko, O. H. (2006). Formuvannia yakosti poroshkopodibnykh Ts- vitaminnykh biolohichno aktyvnykh dobavok iz pertsiu solodkoho, 23.

[4] Kushch, S. P. (2008). Formuvannia asortymentu buterbrodnykh marharyniv pidvyshchenoi biolohichnoi tsinnosti, 26.

[5] Zhuchkov, A. L. (2003). Razrabotka y otsenka potrebytelskykh svoistv plodoovoshchnykh sousov s funktsyonalnymy dobavkamy, 181.

[6] Roliakov, N. V. (2007). Myrovye tendentsyy na rynke ynhredyentov: osnovnoi pryorytet – zdorovoe pytanye. Molochnaia promyshlennost, 10, 11–12.

[7] Sniezhkin, Yu. F., Petrova, Zh. O. (2010). Kharchovi poroshky z roslynnoi syrovyny. Klasyfikatsiia, metody otrymannia, analiz rynku. Biotekhnolohiia, 3 (5), 43–48.

[8] Myller, E. (2001). Fyzyolohychesky effektyvnye pyshchevye ynhredyenty ustoichyvye kontsentraty. International Food Marketing and Technology, 15 (5), 4–6.

[9] Spyrychev, V. B., Trykhyna, V. V., Pozniakovskyi, V. M. (2012). Obohashchenye pyshchevykh produktov mykronutryentamy – nadezhnyi put optymyzatsyy ykh potreblenyia. Polzunovskyi vestnyk, 2 (2), 9–15.

[10] Bilous, O. V., Demidov, I. M., Bukhkalo, S. I. (2014). Doslidzhennia yavyshcha synerhizmu mizh tokoferolamy soniashnykovoi olii ta inhibitoramy okysnennia ekstraktu iz lystia horikhu voloskoho. Visnyk NTU «KhPI», 49, 57–64.

[11] Chekalina, N. I. (2013). Patohenetychne obhruntuvannia klinichnoi efektyvnosti resveratrolu (eveloru). Visnyk problem biolohii i medytsyny, 3 (2 (103)), 51–55.

[12] Yu, L., Wang, S., Kogure, Y., Yamamoto, S., Noguchi, K., Dai, Y. (2013). Modulation of TRP channels by resveratrol and other stilbenoids. Molecular Pain, 9 (1), 3. doi:10.1186/1744-8069-9-3

[13] Reagan-Shaw, S., Mukhtar, H., Ahmad, N. (2008). Resveratrol imparts photoprotection of normal cells and enhances the efficacy of radiation therapy in cancer cells. Photochemistry and Photobiology, 84, 415–421. doi: 10.1111/j.1751-1097.2007.00279.x

[14] Lagouge, M., Argmann, C., Gerhart-Hines, Z. (2006). Resveratrol improves mitochondrial function and protects against metabolic disease by activating SIRT1 and PGC-1alpha. Cell, 127, 1109–1122.

[15] Olson, E. R., Naugle, J. E., Zhang, X. (2005). Inhibition of cardiac fibroblast proliferation and myofibroblast differentiation by resveratrol. Heart, 288 (3), 1131–1138. doi: 10.1152/ajpheart.00763.2004

[16] Um, J. H., Park, S. J, Kang, H. (2010). AMP-activated protein kinase-deficient mice are resistant to the metabolic effects of resveratrol. Diabetes, 59, 554–563. doi: 10.2337/db09-0482

[17] Shin, S., Jeon, J. N., Park, D. (2008). Trans-Resveratrol relaxes the corpus cavernosum ex vivo and enhances testosterone levels and sperm quality in vivo. Archives of Pharmacal Research, 31 (1), 83–87. doi: 10.1007/s12272-008-1124-7

[18] Vingtdeux, V., Dreses-Werringloer, U., Zhao, H., Davies, P., Marambaud, P. (2008). Therapeutic potential of resveratrol in Alzheimer's disease. BMC Neurosci, 371, 1369–1376.

[19] Yokohira, M., Yamakawa, K., Saoo, K., Matsuda, Y., Hosokawa, K., Kuno T., Hashimoto, N., Imaida, K. (2008). Antioxidant Effects of Flavonoids Used as Food Additives (Purple Corn Color, Enzymatically Modified Isoquercitrin, and Isoquercitrin) on Liver Carcinogenesis in a Rat Medium-Term Bioassay. Journal of Food Science, 73 (7), 561–568. doi: 10.1111/j.1750-3841.2008.00862.x

[20] Sadovoi, V. V., Selymov, M. A., Aralyna, A. A. (2011). Poluchenye pyshchevoi dobavky yz vynohradnykh vyzhymok. Yzvestyia vysshykh uchebnykh zavedenyi. Pyshchevaia tekhnolohyia, 5-6, 41–43.

[21] Ambrozevych, E. H. (2006). Osobennosty evropeiskoho y vostochnoho podkhodov k ynhredyentam dlia produktov zdorovoho pytanyia. Pyshchevye ynhredyenty, 1, 30–31.

[22] Tabakeeva, O. V. (2009) Puty povyshenyia byolohycheskoi tsennosty maioneznykh sousov. Maslozhyrovaia promyshlennost, 5, 18–19.

[23] Bobkov, Yu. H. et. al. Hosudarstvennaia Farmakopeia SSSR (XI yzdanye, vypusk 2 «Obshchye metody analyza. Lekarstvennoe rastytelnoe syre»). Available at: http://www.alppp.ru/law/hozjajstvennajadejatelnost/promyshlennost/35/gosudarstvennaja-farmakopeja-sssr---izdanie--vypusk-1--obschie-metody-analiza.html

[24] Palacios, C. (2006). The role of nutrients in bone health, from A to Z. Critical Reviews in Food Science and Nutrition, 46 (8), 621–628. doi:10.1080/10408390500466174

[25] Singh, M. (2004). Role of micronutrients for physical growth and mental development. The Indian Journal of Pediatrics, 71 (1), 59–62. doi:10.1007/bf02725658